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## TECHNICAL MYCOLOGY.

*The Utilisation of Micro-organisms in the Arts and Manufactures: a Practical Handbook on Fermentation and Fermentative Processes, &c.* By Dr. Franz Lafar, Vienna. With an introduction by Dr. Emil Chr. Hansen, Copenhagen. Translated by Charles T. A. Salter. In two volumes: Vol. i. Schizomycetic Fermentation. With plate, and 90 figures in the text. Pp. xviii + 405. (London: Charles Griffin and Co., Ltd., 1898.)

BEFORE Pasteur published his great work on "Fermentation," most people would have scouted the idea that bacteria could ever play any very important part in technical and trade affairs. But when this work appeared it became evident that, as shown in the description of the processes concerned in brewing and vinegar-making, a new era had been inaugurated. Still it was scarcely, even at that time, anticipated that bacteria would come to play their present important part in the arts. Although it is impossible at first sight to appreciate the immense strides that are now being made, it is manifest when one comes to look over such a volume as that under review, that technical mycology has materially aided, and sometimes in a measure even superseded, much of the work of the chemical laboratory. In the case of chemical work, *results* are merely recognised and set forth, but, from bacteriological work, explanation of the chemical changes are afforded. It is interesting to notice what a successful attempt has here been made to amalgamate the scientific with the practical. Hitherto the scientific part of bacteriology has been looked upon as science pure and simple, except in its relation to the production of disease, and to such conditions as putrefaction and fermentation. Now, however, that the scientific investigator and the practical worker are co-operating, it is evident that the import of bacterial processes is greater than could hitherto have been imagined. It has certainly been one of the greatest gains of bacteriology that the study of the physiology of fermentation and other technical processes should have been undertaken by Pasteur and Hansen. Under their leadership there have been brought together a number of eager workers who have from time to time made valuable contributions to our knowledge of mycology. Most of such work, however, is to be found only in technical or scientific journals, with the result that the technologist has not always had the benefit of the opinion of the scientific expert, whilst on the other hand the scientific expert has too frequently worked unavailingly along lines which at the time appeared to lead to no practical result. In the work before us, and in one or two others, especially those that have come from the Danish laboratories, we have a series of text-books, if one may so speak of them, in which both kinds of investigations have been carefully sifted, analysed, collected, and accessibly arranged. It has too long been the case that in certain of the technical laboratories founded specially for the purpose of bringing bacteriological science to bear on technical work, the scientific worker has been kept too closely to analyses and to work having direct relations to technical processes, with the result that in many cases his work has been dwarfed, and he has had little time to devote to original investigation of any kind.

Hansen, in the preface to the work before us, puts the matter pithily and forcibly in the following words:—

> "It is true that an intimate connection with practical conditions sets fresh tasks before the investigator, and exerts on the whole a sufficiently stimulating influence; but on the other hand, the same circumstance gives rise to the danger of diverging into by-paths, and neglecting the strict scientific conditions of investigation. Since these Stations and Laboratories are, as a rule, maintained by a circle of practical men for whom they work, the investigators appointed thereto are often subject to regrettable pressure. Even though, otherwise, a certain amount of freedom is allowed them in these institutions, they labour under the great difficulty of being obliged—whilst engaged in the task of scientific investigation—to be ready at any moment to give assistance—coupled with analyses and any wished-for disclosures—to the parties interested. Still further difficulties arise when practical men foolishly intermeddle in scientific investigations, and especially when results that shall be immediately available for practical utilisation are impatiently demanded—results which, however, are only attainable by scientific investigation, and cannot be forced on at pleasure. . . . The result of these vexed relations between Scientists and practical men has been to call into existence a quasi-scientific literature by which neither Science nor Practice is benefited—a result which every one who has the healthy development of this subject at heart must greatly deplore and endeavour to improve according to his ability. These conditions are, however, in existence, and we must take them into account."

Such being the state of affairs, we welcome most heartily a work which deals in a thoroughly scientific spirit with technical bacteriology, and in the first volume of Dr. Lafar's book we have the part fulfilment of the promise of an exceedingly useful work. Dr. Lafar has given a scientific basis of bacteriology, offering classifications and methods of working which can now be styled classical. But in addition he has drawn up a kind of parallel between the micro-organisms of disease and the micro-organisms that play a part in various technical processes; the whole forming a thoroughly good foundation on which to build up the more technical part which follows. This following part includes a systematic description and classification according to their power of doing work in special technical processes of various groups of micro-organisms. After dealing briefly with the question of spontaneous generation, the author goes on to speak of the various theories of fermentation, and closes the introductory part of the work with a short account of the special organisms that are associated with this process. He then, in the first division of the main body of the book, devotes a section to the schizomycetic fermentations and to the general morphology and physiology of schizomycetes. This is followed by a section on the general biology and classification of bacteria: in this latter section the behaviour of bacteria under the influence of physical agencies is specially dealt with, and mention made of their relation to one another in the various symbiotic, metabiotic, and antagonistic conditions. The account of the various classifications of the bacteria, commencing with that drawn up by O. F.

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Müller, and ending with those now generally in use, is excellent; although it is evident from what is here laid down, that our classification of micro-organisms is as yet to a large extent empirical, and that there is great need for a classification constructed on a thoroughly sound and scientific basis. The principles of sterilisation and pure cultivation are given succinctly but very clearly. The section devoted to the heat-resisting bacteria, their place in nature, and their importance in the fermentation and food-stuff industries, is one of considerable interest. The principal organisms in this group are described as the *Bacillus subtilis* and its congeners, the *Clostridium butyricum*, the genus Granulobacter, and various other organisms associated with the butyric acid fermentation, the fermentation of cellulose, the "retting" of flax and hemp, and the production of rancidity of fats.

The relation of the study of the life-history of these various organisms to the preservation of milk, meat, eggs, vegetables and fruit is fairly carefully considered, as are also the lactic fermentation and the allied decompositions, special stress being laid on the production of optically active organic compounds by fermentation, on the artificial souring of cream, the coagulation of milk, and on the importance of the part that various lactic acid bacteria play in the processes of distilling, brewing and vinification; and in the preparation of fodder, the making of brown hay into sweet ensilage and sour fodder. Then the work done by bacteria in tanning, in the manufacture of sugar in the conditions known as "ropiness" in milk, wine, beer, and other liquids are all somewhat fully and interestingly treated. A special section is devoted to the decomposition and transformation of organic nitrogenous compounds; this, of course, constitutes a very important part of the work, and, in conjunction with the section on oxidising fermentation, affords a very large amount of information on the bacterial processes involved in the breaking up of various organic compounds. It is interesting to note how closely these processes are associated with those of fermentation of cheese and of similar proteid substances.

Altogether this volume, the first of two, is an exceedingly interesting and valuable contribution to the study of technical mycology. The work of translation is well done, but there are one or two slips which might with advantage be corrected in future editions: for instance, "typhus" is throughout used for "typhoid," this, of course, being a literal translation of the German *typhus* without the term *abdominalis*, which is always added to indicate our *typhoid* fever. It need scarcely be mentioned that the work will probably be hailed by English workers with gratitude, but we may point out that the term "mycology" will convey to the general reader very little idea as to the scope of the work. Many years ago a work was published in this country to which the title "Pathological Mycology" was given, a work which was largely overlooked because of its title. Since then this same title has been used abroad, where the significance of the word appears to be more fully appreciated. We think the translator would have been wise had he selected some title more generally "understanded of the people" for what, after all, must to a certain extent be a popular work. There will, however, be a considerable demand for this book amongst those who are engaged in pathological and technical bacteriology, who, of course, will appreciate both the title and the work; but the translator must expect to find that some, at least, of his possible readers will pass over this book simply because they do not understand the title.

Messrs. Griffin have done their part in a thoroughly workmanlike fashion, and we congratulate both author and translator in having their work placed so well before the reading public.

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## *PARTIAL DIFFERENTIAL EQUATIONS.*

*Leçons sur l'intégration des équations aux derivées partielles du second ordre à deux variables indépendantes.* Par E. Goursat. T. I. pp. viii + 226; T. II. pp. 344. (Paris: A. Hermann, 1897, 1898.)

A DIFFERENTIAL equation, in its usual form, states an analytical problem with a certain assumption as to the form of the answer. It implies the existence of a dependent variable, capable of being differentiated so far as the order of the equation indicates; and the solution of the equation consists in discovering a relation among the variables, free from differential coefficients, such that the given differential equation may be derived from it. The question at once arises: what is the most comprehensive form of solution? Is it possible in every case to define an integral relation connecting the variables equivalent to the differential equation in the sense that not only is the differential equation derivable from it, but every possible relation consistent therewith is included as a particular case in the integral equation? In the early days of the infinitesimal calculus it was observed that ordinary differential equations could be obtained by eliminating constants; while partial differential equations could be derived by the elimination of constants or of arbitrary functions. In some cases the reverse process of starting with the differential equation and arriving at an integral relation, involving arbitrary constants or functions, or both, was found to be practicable; and it came to be taken for granted that integral relations of this kind always existed, the only difficulty being that of discovering them.

But, with the advance of function-theory, the peculiar difficulties of the subject have gradually become more evident. It is true that, with regard to ordinary differential equations and partial differential equations of the first order, the general form of solution has been established, and the hypothesis of the earlier mathematicians justified; but when we come to partial differential equations of the second and higher orders, the aspect of the problem is radically changed. In most cases it is hopeless to attempt to assign an explicit form of the general integral, or even to prove its existence; and we have to content ourselves with the study of solutions subject to certain special limitations. Thus we have the problem of Dirichlet in the theory of potential; or again the problem of Cauchy, which forms the leading idea of M. Goursat's original and fascinating treatise.

To explain what this means, let us take the case of an equation of the second order with two independent variables, say $\phi(x, y, z, p, q, r, s, t) = 0$, the notation being as usual. Assume $x, y, z, p, q$ functions of a single variable, subject solely to the condition $dz = pdx + qdy$; we thus

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